I INFORMATION AND PRE-TRIP ACTIVITIES

Chapter One WHAT ARE REDWOODS?

What is a redwood tree?
What size are redwoods?
How large are they underground?
How are other trees like the redwood?
How is the redwood different from other trees?
Are all redwoods exactly the same?

Have you ever wandered through a redwood forest? Or seen a redwood that is planted in your community? Maybe you've only seen books, postcards, and posters? How about a movie or a slide show? Even if you've only sat on a redwood bench, you know something about redwoods. Oh, you've lived your whole life among the redwoods? Well, no matter how much or how little you've seen of redwoods, whatever you've noticed will help you as we begin to discover more about this magnificent tree.

The following story may be read to younger students to help them imagine what the forest is like. It might help them if they close their eyes while you read.

As we step from the bright green lushness of a flowering meadow we find ourselves at the edge of the forest . . . a few more steps and we have left our companion, the sun, far behind. Cold shivers run up our spines! A quiet hush stirs all around us. The activity of the buzzing and crawling meadow creatures disappears in the darkness of the forest. Every footstep upon the cushion of dead and decaying leaves and twigs takes us deeper into the cool, silent forest. Then Hugh's whisper breaks the quiet.

"Each step we take crackles. Don't you think it sounds like walking on creaking floors in an empty house?"

"Hey, how come we're tiptoeing and you're whispering, Hugh?"

"Shhh. Look at this stuff we're walking on! It's like a mat – all hooked together. Stick your fingers into it, Sal."

"How deep is it? Hey, I found something!"

"What is it?"

"I don't know, but it looks like a tiny pine cone, and it has little seeds."

"I've found one, too. Where could they have come from? Hugh, look up. Do you suppose it came from up there? Look, do you see what I see?"

Have you ever put yourself on the legs of an ant before? Did you ever wonder what a blade of grass might look like to such a small creature? Hugh and Sal suddenly realized where they were. Can you see them lying on the ground, deep in the forest, looking up at the tallest living trees in the world? For a moment they might have seemed to themselves like ants among blades of grass.

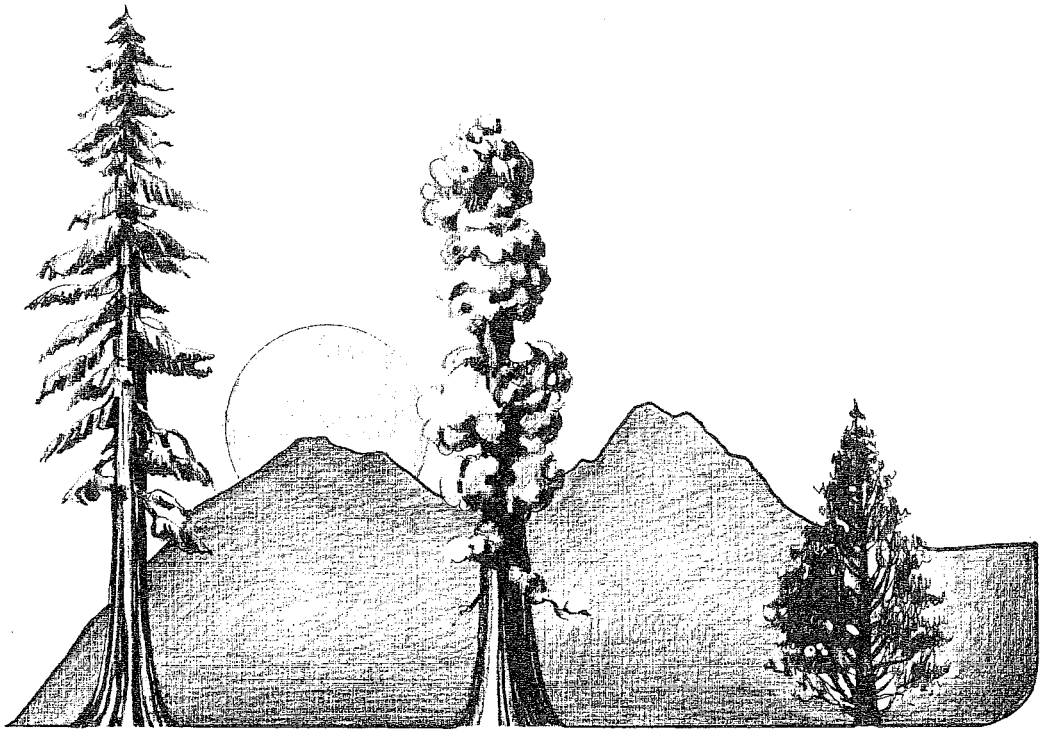
A coast redwood, like other trees, is built of many working parts. Beneath the soil grow many roots. They have several jobs. They are like your feet. They give the tree balance and stability. How great an expanse of roots do you think it would take to balance a single coast redwood? (No need to answer this one, but you might like to wonder about it.)

Roots are also like our hands. They are the fingers on the tree that reach for all the nutrients and water they can absorb from the soil. Roots can store minerals for the tree until they are needed. Some plants have one large taproot to bring up water and nutrients from far into the soil. Others, like the coast redwood, grow in moist areas where much water is available near the soil surface. These trees, then, need only a shallow, spreading root system in order to obtain water.

Most coast redwood forests are very dense – many of the trees grow side by side. Try to picture the root systems of these trees as a single network. How might this improve the balance of a single tree? Might this "close-knit" situation also affect the forest as a whole?

Above the ground the coast redwood, like other trees, is equipped with a trunk, branches, leaves, and a means of reproduction. High in the trees, leaves absorb and convert the sun's energy into sugars and starches that allow the tree to grow new roots and leaves, a taller trunk, and cones to produce new trees.

Although each of these parts has the same function in most plants, those of the coast redwood are distinct in appearance. Some trees very similar to the coast redwood in these characteristics are considered its relatives. Below are some pictures and a chart to help you see how the coast redwood and its relatives are similar yet different.



	Coast redwood	Big tree	Dawn redwood
Location and distribution	500-mile range from Santa Lucia Mountains north to southern Oregon; elevation 0 to 3,000 feet	250-mile range in the Sierra Nevada Mountains from Tulare Co. north to Placer County; elevation 5,000 to 8,000 feet.	Central China; elevation 2,400 to 4,000 feet.
Reproduction	Reproduces mostly by sprouts, sometimes by seed. Cones are smaller than those of the dawn redwood. Cones mature in one year. Young trees can tolerate shady areas. The trees often grow in pure stands of redwood. Growing seasons are long. Rate of growth may be fast if conditions are good.	Reproduces only by seeds. Cones are large – up to two-and-one-half inches. They mature in two years. Young trees need much sun. This species grows in mixed stands; i.e., among several other types of trees. The big trees grow very slowly.	Reproduces by seed. Cones are very small. This tree grows relatively fast, particularly when it is located by a stream. Growing seasons are long.
Average diameter	12 to 16 feet	28 to 32 feet	5-1/2 to 6 feet
Average height	300 to 360 feet	250 to 300 feet	80 feet
Maximum height	367 feet	325 feet	115 feet
Average mature age	800 to 1,500 years	2,000 to 3,000 years	Unknown
Oldest known age	2,000 years	3,300 years	500 to 600 years
Root system	Spreads 40 to 50 feet; depth, 4 to 6 feet	Spreads 100 to 150 feet; depth, 6 to 8 feet	Unknown
Leaves	Evergreen	Evergreen	Deciduous
Scientific name	Sequoia sempervirens	Sequoiadendron giganteum	Metasequoia glyptostroboides
English meaning	Always living	Giant sequoia	Akin to sequoia

Chapter Two DISTRIBUTION AND ANCESTRY; ADAPTATION AND EVOLUTION

What does a plant need to live?
Do all plants have the same requirements?
Where do redwoods grow?
Have they always lived where they do now?
Why don't they grow elsewhere?

Have you ever taken care of a plant? What did you need to do for it? Where did you keep it? How is caring for a plant similar to caring for your own body? How is it different?

A plant's needs are a lot like a human's. In order to grow, a plant needs vitamins and minerals just as we do. In addition to nutrients from the soil, however, a plant requires sunlight for energy and growth. Another basic difference between plants and man is the inability of the plant to move from its rooted positon. When we are too hot or cold, we can add or subtract clothing or change locations. If we are hungry, we can feed ourselves. But a plant must be able to survive in the limited environment in which it grows. If the soil is unfertile, too wet or too dry, or if the leaves are getting too much or too little sun, then the plant may die. Survival only occurs when the plant can tolerate and adapt to the conditions in which it grows. No environment or organism is static.

Just as the earth has been changing for billions of years, so have the organisms that occupy the land, sea, and air. In the severe seasons, only the most well-adapted individuals will survive and reproduce. In this way the most successful organisms pass on their characteristics to the next generation. In this slow process we call evolution are born the changes that allow organisms to change with the earth. And so it is that the three living redwood species have been subjected to different environmental conditions, and each has responded uniquely and successfully. Many other species that could not make necessary changes have died out.

What do we know about the ancient past of the coast redwood? At one time redwood trees grew in many parts of the northern hemisphere. The world was then a different place. Dinosaurs roamed the countryside, and huge swamps were common. The climate was much warmer because this was before the Ice Age and the formation of the northern glaciers. During this early, warm period, redwoods even lived in Alaska! How do we know this? Fossils of several different redwood species have been found in rocks in many parts of the northern hemisphere. Other plants, such as giant ferns, figs, avocados, and mahogany, are known to have occupied the same areas. Where do we find them today and in what kind of climate? To see these plants growing wild today, we would have to travel to the subtropical rainforests in Mexico or Central America. Why don't we find these plants in Alaska or California now?

Gradually, the earth and climate have been changing. Days and seasons have become much colder, the air and soil drier. Plants and animals have been forced to change their habits or bodies, to migrate, or to succumb. Today we find very few survivors of the past. What do you think happened to them? The dinosaurs disappeared long ago. So did most of the plants. However, the coast redwood, which once occupied many different areas throughout the United States, Canada, and western Europe, is now living only along a 500-mile stretch of coast in northern California and southern Oregon.

Have you ever wondered why the coast redwood is limited to such a small range or how it is suited to this particular natural habitat? The Pacific coast has a damp, mild climate all year round. Temperatures fluctuate very little from season to season, and fog covers the trees in a wet mist during much of the summer. Coast redwoods grow very straight and tall and close to other trees in the forest. The dense foliage collects the mist from the air. What does this do for the tree? Just beneath the soil surface grows a delicate system of feeder roots. As the water drips from the leaves to the earth, the roots take up the moisture. Because the trees are so tall and close together, sunlight rarely reaches the forest floor. This, too, helps to keep the roots moist and the tree supplied with the necessary water to live through the usually rainfree summers.

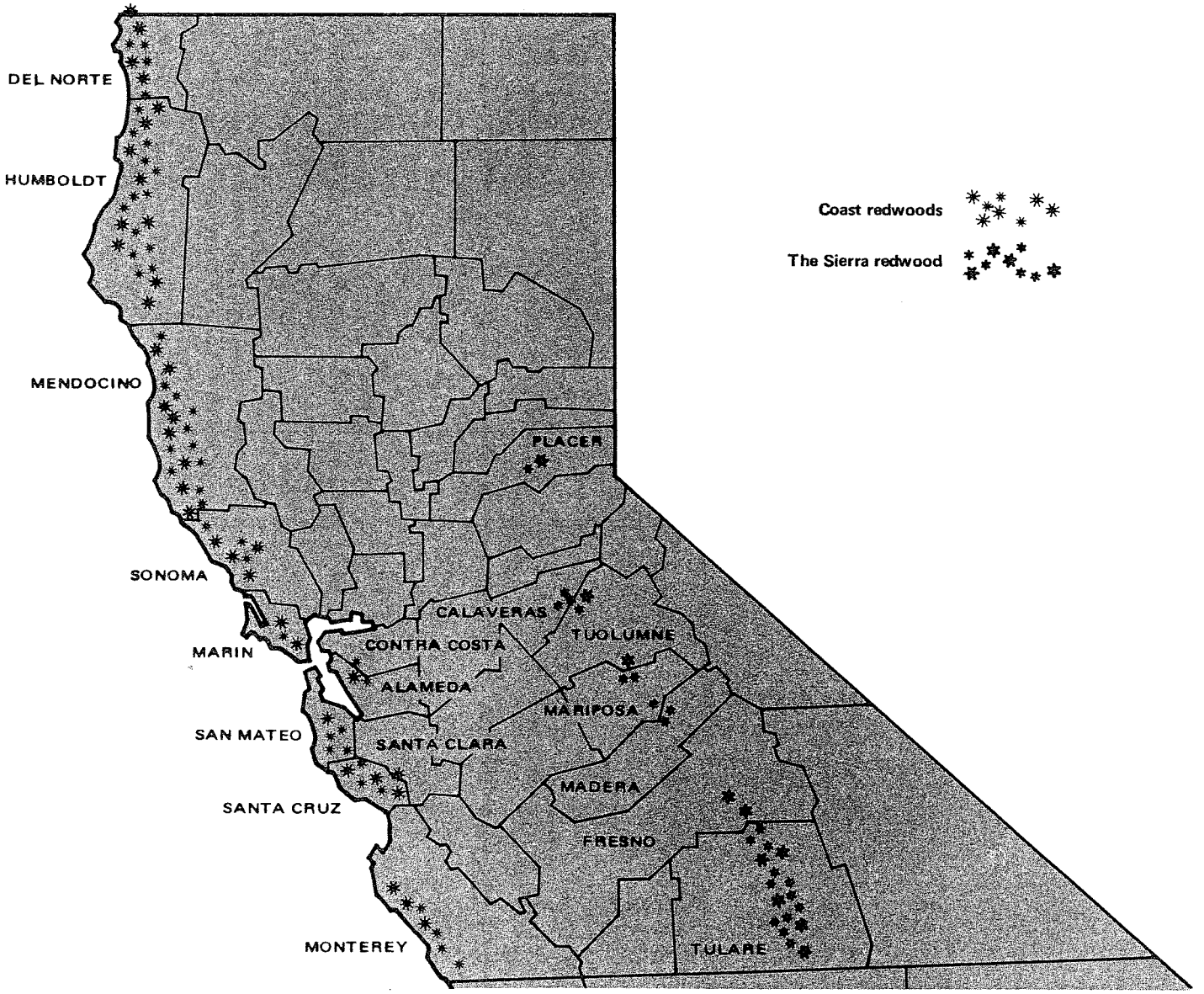
Is a damp, mild climate the only thing a coast redwood needs to survive and prosper? What other requirements does this tree have? The coast redwood grows the largest and healthiest and in pure stands where water, soil, and light are all abundant. The combination of these elements is at a peak in some coastal river valleys, where soils are continuously washed down the canyons or blown by eroding winds. These "new" soils are rich in minerals and the steady resupply allows redwood groves to grow and remain healthy. Do you have an impression of the coastal zone, its climate, and why the coast redwood survives only in this small habitat range?

Another California redwood, the big tree, grows naturally in a small range of about 250 miles on the western slopes of the Sierra Nevada. The climate here, with its seasonal fluctuations, is very different from that at the coast. Winters are much colder, and some snow is common. Summers are very hot and dry. Do you think the coast redwood could live there? Why not? What features of the big tree help it thrive in an area where its coastal relative cannot even survive? For help turn to the chart in Chapter One. How are these two trees different? Why do you think the deeper and farther-spreading root system of the Sierra Nevada species is useful in the dry climate?

Let's consider the leaves of the three living redwood species. What do we find? How is each unique?

The big tree has leaves that are much smaller than those of the coast redwood. This enables the tree to conserve water. Leaf surface exposed to the sun loses some water due to evaporation. In the case of the coast redwood, the leaves are larger and the foliage is much denser. Much of the sun's heat is lost before it reaches the lower branches of the tree. Oftentimes the upper branches have much smaller leaves that closely resemble those of the big tree.

The dawn redwood, thought to have been extinct for 20 million years, was recently discovered living in Central China. It has adapted to the seasonal freezing temperatures by losing its leaves during the cold season. Many plants, such as some oaks, maples, and elms, conserve water and energy by being deciduous. What other characteristics do you think help these trees to live in their particular habitats? (Let the students speculate.)



Chapter Three

GROWTH AND REPRODUCTION

Where does a coast redwood seed begin to grow?
Why don't all seedlings survive?
How fast do coast redwoods grow?
Why do coast redwoods regenerate themselves by sprouting?

Did you know that coast redwoods, like other conifers, have both male and female cones? Both sexes can be found on separate branches of the same tree from March to November. The cones that you are probably familiar with are female cones. They contain the seeds that begin new trees. Do you think you've ever seen the tiny, inconspicuous male cone? It is made up of pollen that must unite with a mother cell in the cone to become a seed. How does the pollen reach the female cone? The wind plays a large part in this event. Many seeds are produced by each tree every year, but few survive. Still fewer will produce seedlings because of limited habitat conditions. During the late summer and fall most of the seeds drop from the cone to fall among the old trees of the forest floor. Who knows where the little seed will land? Can you think of several natural forces that might help to bring a seed to its final place of rest?

Coast redwood trees produce millions of seeds every year. How many of these ever land in a place suitable for the beginning of life? Will they get enough water to germinate, enough nutrients from the soil, and enough light to survive and produce a new tree? Very few trees make it past the seedling stage. Why does this happen? What do so many young redwoods need that they aren't getting?

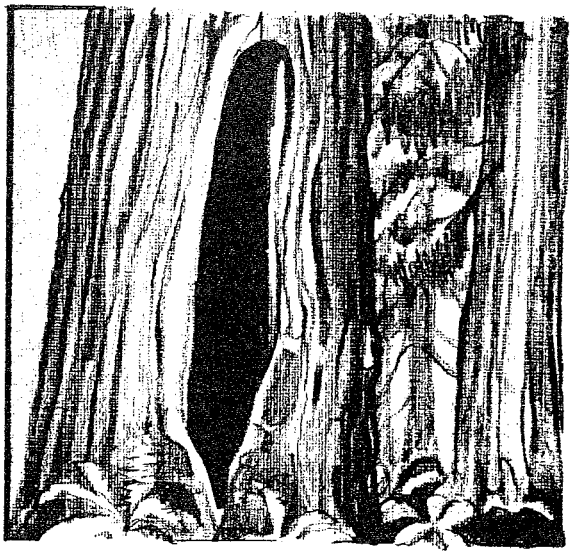
In order to germinate, a seed must get enough moisture to soak up its seedcoat and high enough temperatures to begin growth. Usually this means about five to eight inches of accumulated rainfall and days warmer than 58°F. If the young seedlings can survive longer than three months, they've made it through the roughest period. By this time a seedling is well established. Roots may have pushed three to four feet into the soil and begun to branch off in several directions. But before a seedling gets to this point, many events must have occurred. This is why few seedlings mature to the reproducing stage.

First, the seed must contact mineral soil, which lies six to eight inches below the litter layer. How does the tiny seed get in touch with the rich soil? A disturbance, either natural or caused by man, may allow this to happen. A tree may fall, an area may be logged and the soil upturned, or a flood may bring in new soil. Burned areas are also the site of many young seedlings. The thick layer of dead plant materials on the soil surface is burned away, the bacteria are killed, the mineral soil is exposed, and the microorganisms that attack the roots and stems of tiny seedlings are dead. Under these conditions, when the soil has been naturally prepared, and the dense ceiling of the forest canopy has been thinned, light, moisture,and warmth work together to produce a healthy, thriving seedling. Is it clearer to you now why so few of the millions of seeds that fall to the forest floor grow to be the giants that we see in photographs and visit in our parks?

Sprouting is considered the major form of reproduction of the coast redwood. Buds on the roots form vigorous, fast-growing sprouts. Sprouting may also be a reaction to an injury inflicted on the tree. For example, when a tree is felled or burnt, it may sprout. In any case since the root systems are already developed and light is readily available, the sprouts shoot up, and the forest is soon very green. Healthy trees produce a growth regulator that inhibits fast-growing sprouts. These trees concentrate all growth in the main trunk and branch system. Injured or declining trees don't produce these regulators, and the sprouts soon take over. Sprouts are very persistent, and young seedlings aren't able to compete with them for resources.

Oftentimes forests have a "fairy ring" of trees that are all sprouts from the same parent tree. The older center tree may or may not be living, and in some cases it will be completely decayed. Sometimes you will see sprouts that seem to appear out of nowhere. Often these are sprouting from burls beneath the soil on fallen logs or on the roots themselves. These gnarled masses of dormant buds are centers for sprouting and do not disrupt the functions of the tree. Wood craftsmen consider burls valuable building materials.

Chapter Four SURVIVAL



What enables a redwood tree to live so long?
What are the enemies of the coast redwood?
What happens to a redwood forest in a fire? In a flood?

How long does a coast redwood live? Some of the oldest have been alive 2,000 years or more, but on the average they survive for 800 to 1,500 years. Does this seem like a long time to you? What events in history were occurring in the late 400s when some of these older trees were small seedlings. Columbus wasn't even to be born for another 1,000 years!

How can a redwood live so much longer than most trees? What is special about the structure of the coast redwood that enables it to survive so long? What usually does kill the tree? Redwoods have several natural enemies — insects, disease, flood, fire, wind — but they are also equipped with amazing abilities to combat these forces.

How do you think insects penetrate trees? Most insects bore into trees through the bark, but in the redwood this is particularly difficult. Redwood bark is fibrous (dry and full of air pockets) and very thick. Tannins, produced by the tree, are found in the bark. The bitter taste of this substance, combined with the other factors, makes the bark a very unpleasant place for insects. The thick bark also protects the inside of the tree from fire.

Very hot fires often burn the inner heart wood of the tree. Have you ever seen a redwood with a big cave-like hole in the base of its trunk? How can the tree continue to live with its interior burned away? Since the tree is still living, how important can the outermost layers of the tree be? This part of the tree, the cambium layer, is the most recent growth of the tree. It is alive and produces a new layer of bark and wood each year. The loss of the center support of the tree does definitely weaken the tree and make it more susceptible to damaging natural forces, but it doesn't kill the tree.

What happens to you when you get cut? Your body heals itself, doesn't it? Redwoods heal their wounds, too, but only very slowly. If your cuts don't heal quickly, bacteria and virus diseases may enter and grow in your body. Wounds in redwoods may be invaded by very slow-growing molds and fungi, but it is rare that these trees are killed by disease.

How are these magnificent trees affected by flooding? The largest, most beautiful coast redwoods live in the river valleys, where the new mineral soils are regularly available through the seasonal processes of wind erosion and flooding. Have you ever watched a river during a storm? What color is it? When great amounts of water fall over a short period of time, the land cannot hold all of the water. It drains into the rivers, which then swell and erode the banks.

Soil, branches, and other debris are absorbed and carried by the river. The river, swollen with these materials, leaves its normal course. Because it cannot travel so fast here, much of the dirt and debris settles out. If this happens year after year, the land on both sides of the river flattens. These areas contain some of the richest available soils and make superior homes for the coast redwoods.

But doesn't this regular flooding harm the redwood, whose roots need to be close to the soil surface? As we have already seen, this remarkable tree has developed the ability to combat many natural forces. When the roots are buried beneath a thick layer of topsoil, the tree quickly sends out new roots, first straight out from the old root system. Then, a completely new set of roots grows from the trunk at the point just beneath the new soil level, where minerals and moisture are most abundant.

So we see that the natural forces of the river have a tremendous effect on the coast redwood forest. New mineral soil is introduced fairly regularly, allowing young seedlings a good opportunity for survival. Maturing trees also benefit from the abundant nutrients. And the weaker, sickly trees are naturally harvested by the raging torrents. In some cases rivers rise too rapidly and race through canyons so quickly that an entire forest may be wiped out. These areas aren't so quick to recover, and erosion can be a major problem here.

Chapter Five THE REDWOOD COMMUNITY

What plants are the redwood's neighbors?
What animals make their homes among the redwoods?
How do these organisms interact to make up the redwood community?
What happens when a member of the community dies?

As a strong, swift wind blows through the forest, the creaking of an old redwood swaying back and forth is heard over a short distance. But this is not the usual forest sound, as you might be thinking. For many roots of this old tree have long ago burned away, weakening the tree's balance. During the recent rains the softening earth has unknowingly been preparing a bed on which this tree will lie for many years to come. The wind continues to race through the forest until finally a single, huge thrust rocks the tree, loosening the soil just enough. The earth gives way. The tree crashes to the forest floor, shaking the earth. A hushed silence comes over the forest, and the old redwood rests.

In falling by the natural forces of the earth, this old tree remains an intricate part of the forest's web of life. With the death of the redwood comes a surge of life to the forest floor. This single change brings a disturbance of the soil and more readily available nutrients, more space to grow, and a place where light can easily reach the floor. As the leaves, branches, and trunk of this mighty tree are attacked by bacteria, insects, and fungi, the woody material will be returned to the soil, where it can once again initiate new life and growth. This tree will decompose in time and bring nutrients to redwood seedlings, maturing adults, and the plant neighbors that will live in this community for many years to come.

Do you know what plants are neighbors of the redwoods? Do you know what they are like and how they fit into the redwood community? What is the role of each plant and animal that lives in this area? How does each depend on the other? These are things we will try to discover as we take a close look at life within the redwoods.

A redwood community is many different things:

1. The foliage of many redwoods growing so close together blocks out much of the potential light source of many other plants.

2. The dense foliage captures fog, which drips to the forest floor beneath the tree.

3. The three-to-four year old sprays of leaves periodically fall from the redwood to the forest floor and accumulate there – a part of the long process of decay.

Keeping all of these things in mind, how should we describe the forest floor? Think of this dark, wet environment. Though conditions seem pretty bleak for any kind of undergrowth, the redwood habitat is the home of a variety of plants that find the surroundings suitable for growth and survival. For example, some of the herbs found on this forest floor have been associated with the redwood for millions of years. Without the protection this environment provides, these fragile plants would have been forced to change or to succumb. Also at the floor level are several different ferns. The largest you'll see is the sword fern. Look at the back of the leaf. The moisture of the floor is very important for the growth of these spores, which are the reproductive cells of the ferns.

The California huckleberry, a shrub, is larger and taller than the herbs. It shares the second layer of growth with other plants that are also shrubs and require more light than the herbs do. Can you think of a reason why berry-producing plants are important to members of the community?

The rhododendron, a beautiful flowering plant, is also found within the shrub layer. It, as well as many of the other shrubs, grows well in the community because it can tolerate a highly acidic soil. Because not all plants can grow in this soil that the redwood produces, competition is reduced for those that are able to survive here.

The upper layer of growth is made up of a variety of trees, depending on the microclimate of the particular area. For example, the Douglas fir, a conifer, can thrive in the subdued light of the redwood forest. For this reason it is a close associate of the coastal sequoia. On completely cleared slopes its seedlings are able to germinate and survive better than redwood seedlings. Later, under the protective branches of the "pioneer" Douglas fir, the redwood seedling is able to get a good start. Other species do better with more light, and they are always fighting to grow closer to the sunlight. These types of plants do much better at the edge of the forest. Still other trees do best near streams. Where the redwood forest borders the ocean, we get a wholly different group of tree associates.

So we see that there is a great variety of plants that lives near or among the coast redwoods. More important than knowing the names of these plants is acquiring a clear picture of the forest layers. Notice that the habitat is not uniform. Do you see that there are different plants at each level within the forest and that geographic location determines which plants will grow at a particular site? For instance, companion plants in the river valleys, the inland canyons, and the coastal mountain ridges are all different. Why is this important?

The great diversity of plants within different layers creates a community of many different niches that can be filled by a variety of organisms. Moles, shrews, bats, squirrels, porcupines, birds, and other animals inhabit the redwood forests, at least periodically. Since the forest isn't very productive, these animals aren't extremely abundant. Each creature must play a unique role in the community if it is to live and reproduce here. That is to say, each species has a different home and way of life from all others. However, the whole community is linked together in a loosely knit but intricate web; each plant and animal is dependent on others.

One of the most abundant food sources for animals of the redwood forest consists of insects. What kind of animals eat them? When you walk through a forest, listen for sounds. What do you hear? Different birds, each with a unique niche, inhabit the different layers of the forest. Some occupy the uppermost branches and search among the topmost leaves for food. Others climb the massive trunks of the redwoods, actively searching for sparse bark beetles. Still other species scrape in the floor litter for a morsel of food.

Notice the different feet and beaks of each type of bird you can get close enough to see. Try to decide what eating habits the bird has by looking at its body parts carefully and by watching it move. One bird you'll be sure to see among the redwoods is the only blue-crested bird in California, the Steller's jay. Oftentimes it will screech and squawk and warn all the forest animals that you are approaching. The banana slug probably won't be quick enough to escape your eyes, but do watch your feet, or you'll squish this well-camouflaged yellowish creature.

Be sure to keep your eyes and ears ready for anything because the redwood forest hides many animal homes, and you may be lucky enough to find one. Do you see a good place for a bat to hide from the light? Is there a niche for a salamander in the forest? Do you think a deer would find enough to eat here?